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VERTICAL INTEGRATION AND PRODUCT QUALITY
IN THE EARLY COTTON TEXTILE INDUSTRY

by

Peter Temin

No. 477 February 1988

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Vertical Integration and Product Quality in the Early Cotton Textile Industry

Peter Temin
MIT

Among the issues that engage scholars of British industrialization is the question of industrial organization. Gerschenkron argued that Britain, as the first industrial nation, could industrialize on the basis of small firms interacting in open markets. Kindleberger suggested by contrast that the specialization of British firms retarded technical change and economic expansion late in the nineteenth century. More recently and specifically, Lazonick has argued that the separation of spinning and weaving in the late nineteenth-century Lancashire cotton industry was a "constraint" on progress in that industry. This vertical specialization was, according to Lazonick, a result of the cotton industry's past. (1)

This article examines vertical integration in the early years of the cotton industry--in the first half of the nineteenth century--in both England and the United States. There are several questions. First, was the contrast in vertical integration so apparent late in the century present as well before about 1850? Second, which firms were more likely to be vertically integrated in the early nineteenth-century? Third, how does the answer to the second question help explain the international differences? The answers rely on factors ranging from the technology of weaving to the politics of the American tariff.

The answers also necessarily involve a theory of vertical integration. The current theory of vertical integration is based on transaction costs. The transactions-cost analysis is created by "joining bounded rationality with opportunism." (2) Starting with Klein, Crawford and Alchian, it increasingly has emphasized asset specificity, the extent to which assets used in a specified way would have lower value in any alternative use. (3) Four dimensions of asset specificity have been identified by by Williamson. They are the advantages of a specific site, of specialized physical capital, of specialized human capital, and of dedicated assets. (4) If production costs would be increased by foregoing the use of an asset with one or the other of these attributes, then the owner of the specific asset acquires some market power. Given the durable nature of the asset, this power could be exploited opportunistically once the capital was in use. To avoid this, the buyer of the services of the specialized asset would like to have a complete contract, but the presence of bounded rationality makes it costly to write complete contracts for an asset with any of these characteristics. When its use is indicated, therefore, some sort of integration is indicated, whether through long-term contracts or incorporation within a single firm, that is, vertical integration.

Empirical tests have revealed a relationship between asset specificity and various forms of vertical integration today. Monteverde and Teece found that automobile companies were more likely to integrate backward into the production of components if engineering was important or if the item was made by a single

supplier. Masten found that aerospace components were more likely to be made internally if they were highly specialized and "complex." Joskow found that vertical integration between electric utilities and coal mines was much more likely for mine-mouth generating plants than for others. In each case, variables indexing asset specificity significantly affected the decision whether to obtain the desired products through the market or internally. These three examples illustrate the importance of human capital, physical capital, and site specificity, respectively. (5)

The transaction cost variables can be contrasted with the entirely separate set of variables of traditional economic theory, which emphasizes the costs of production. Steel mills integrated with blast furnaces, for example, to avoid the cost of cooling the pig iron and then reheating and remelting it. But while conventional analysis looks to different costs, it does not constitute a separate theory. For it is only the transaction costs of concluding a sale for molten pig iron before it cools that prevents two geographically integrated firms from being organizationally disjoint.

Despite the ability to embed any integration argument in a transaction cost framework, it is worth distinguishing the two approaches. Transactions cost elements will be identified here with asset specificity of the sort described in previous tests. Traditional theory will be identified with the profits to be made by the use of assets or products that could be used as well by

different firms or in different contexts. A few articles have approached the topic in this spirit, asking if transaction costs or conventional costs provide better guides to behavior. Mulhearn and Spiller, for example, both find that modern patterns of vertical integration are more consistent with transaction cost analysis than traditional cost analysis. (6) While I do not propose here to test formally the historical usefulness of transaction cost analysis, it is illuminating to keep in mind this distinction among variables for an informal exploration.

The Question of National Differences

Despite its reputation as vertically specialized, the British cotton industry always was vertically integrated to a substantial extent. Fully 60 percent of Lancashire cotton factory operatives were employed in establishments that combined spinning and weaving in both 1841 and 1856. The proportions were lower after those dates, integrated firms still operated over 50 percent of spindles and 40 percent of looms in 1890. (7)

The picture is more clouded before 1841. Lyons suggests that it was not dissimilar, but there are problems with his view. Even before the widespread use of power looms, he argues, many British cotton firms were vertically integrated. Of the almost 800 Lancashire spinning "firms" listed in Baines' Directory and Gazetteer in the mid-1820s, he asserts that 40% were vertically integrated. Three quarters of these "firms" were integrated with hand-loom weaving. (8)

The problem comes with Lyons' identification of Baines' entries as firms. The directory label on the relevant lists is: "List of inhabitants--Arranged according to the Professions and Trades." (9) It is likely that most of the 800 Lancashire "firms" cited by Lyons were in fact individuals. The directory therefore may tell us about the different activities carried on in some households, as opposed to firms. It would be interesting to know the volume of output from each "inhabitant"--as an index of the number of people included under each listing--but it was not included.

Baines did make a distinction between "spinners" and "spinners and manufacturers." Since manufacturers presumably made cloth, Lyons classified the latter as vertically integrated. But the extent to which these were integrated firms, as opposed to families with both spinning apparatus and hand looms, is unknown. Lyons has alerted us to the existence of integrated firms using hand-loom weavers, but it is still likely that vertical integration in Lancashire was increasing during the first half of the nineteenth century.

Just as not all British cotton firms were vertically specialized, not all cotton firms were integrated in the United States. Vertical integration was typical of Waltham, or Massachusetts, style firms. Other firms, often known as Rhode Island style, often confined their activities to spinning. Scranton noted the similarity between textile manufacturing in Philadelphia and Lancashire. The similarity appears to extend to

vertical integration. But just as recent research suggests that the early Lancashire industry was more integrated than has been thought, so was the non-Massachusetts American industry. In New York State, for example, over two-thirds of cotton spinning mills combined spinning and weaving, even though the size of the integrated establishments was far, far smaller than that of Massachusetts mills. (10)

Although Massachusetts mills expanded rapidly relative to Rhode Island style cotton firms in the early nineteenth century, Davis and Stettler estimated that they produced only half of industry output on the eve of the Civil War. (11) While vertical integration in the United States cotton industry was pervasive, therefore, it was not universal. Most verbal accounts portray the Anglo-American difference as black and white, but the data reveal it to be different shades of gray.

In fact, the overall shade may not differ much between the two countries. The variations within the countries may be more striking and more interesting. The continuation of some integrated and some specialized firms over time--at least in England--suggests that the costs of operating in the two modes were not too different. Can we discover in the historical record those attributes of firms that made them organize one way or the other?

Vertical Integration in Great Britain

Cotton spinning factories began to appear in the late

eighteenth century as successive generations of spinning machinery were invented. Most of them were not vertically integrated, producing yarn for hand-loom weavers. In fact, the increased supply of yarn ushered in a short-lived golden age of hand-loom weavers around the turn of the century. As the wages of English hand-loom weavers rose, the cotton mills began to export yarn to weavers in India.

A power loom (the Horrocks loom) was invented in 1803, but was confined to the production of "plain goods"; hand-loom weavers were cheaper for "superior and fancy goods." There were two dimensions of quality for woven goods as they emerged from the loom. They could be "fine" or "fancy." Fineness referred to the count of the yarn used, with high counts indicating finer (thinner) cloth. Fanciness was a characteristic of the weave, but there is no single-dimensional ranking of weaves. The exploration here therefore must be limited to only one dimension of quality: fineness. (All of the quality added in the finishing and dying stages is ignored as well.) Widespread mechanization of weaving came only with the introduction of the Blackburn plain loom, invented in 1828 and made automatic in 1841. (12)

By this date, as noted above, 60 percent of Lancashire factory operatives were in integrated factories. The question is why vertical integration had increased over this period. I suggest that it was connected with the introduction of the power loom, although it was <u>not</u> as simple as the addition of power weaving sheds to existing spinning mills.

Asset specificity was not an issue. This was not a new industry nor a frontier setting. There were almost 1,000 cotton factories in Lancashire in 1841, one-third of them integrated. The yarn that was produced was sold by count and grade on a Manchester exchange. Extensive standardization of yarn types reduced the transaction costs of buying yarn to a low level.

These transaction costs did not vanish, however. When a firm was in a position to use power looms to weave yarn that it had spun, there was an advantage to integrating these two operations. But when a firm spun cotton that was too fine for the primitive power-weaving technology of the early nineteenth century, there was less incentive to integrate. The yarn was marketed abroad or woven by hand-loom weavers. Some of the latter could be included in the firm as outworkers, but most worked for separate putter-outers.

Firms engaged in "fine spinning"--defined in 1833 Manchester as spinning counts above 90--did not integrate vertically. (The count is the number of hanks of 840 yards of yarn to the pound.) Many, but not all, of the firms engaged in "coarse spinning" did.

The impetus came from spinning firms. There were few economies of scale in weaving, and power-loom weaving always was done by many small firms. Even so, hand-loom weavers, whose wages had declined since the 1820s were not in a position to raise even the small amount of capital needed to obtain a power-

loom. The owners of cotton spinning factories, by contrast, were well placed to raise capital to buy power looms. Of the 269 integrated firms using power looms in 1835 analyzed by Lyons, over two thirds of them had been engaged in spinning at the time they adopted power looms and 20 per cent were new entrants to the industry. Only about 10 per cent of the integrated firms were independent weavers who had added spinning to their activities. (13)

The hypothesis then is that owners of spinning factories were installing power looms because they could finance and operate them most cheaply. Among cotton spinners, those who could weave their own yarn would have lower costs of production than their colleagues who had to sell their yarn output and buy different yarn to weave. Since power looms worked best on lower count yarn, "plain goods," spinners of lower count yarn should have been more likely to add power looms than spinners of finer yarn. Integration, in other words, should be inversely related to the count of yarn spun.

The owners or projected owners of larger spinning mills would be more likely to integrate with weaving than the proprietors of smaller mills making the same count of yarn. For one thing, they probably were able to borrow more cheaply, assuming something like a fixed transaction cost per loan. This cost could have been either the cost of arranging for the loan or the cost of reaching agreement in a world of imperfect information. For another thing, if mills wove a distribution of

counts, then a larger mill would be more likely to spin some coarse yarn suitable for power weaving than a smaller one with the same mean count.

The hypothesis thus assumes that entrepreneurs chose both the size of their spinning operation and the quality of their yarn, at least as indexed by count. Then the issue of weaving was made conditional on these earlier decisions. The choice of count and size, however, may not have been independent. If not, I assume that the choice of product was primary. To the extent that size was dependent on product quality, it did not exert a separate influence on integration.

This hypothesis can be tested with data from a survey of Lancashire cotton mills in 1833 by the factory inspector, John W. Cowell. The data were codified by "an eminent accountant in Manchester" who had assisted in drawing up the survey forms. After six months of preparation, the inspector was able to present data on 300 firms, about half of which were considered to be complete. (14) Ure reproduced the table of complete returns, which contains usable data on 144 mills (plus three who only wove and therefore did not report the count of yarn spun). An additional 21 observations can be extracted from the original tables. These are entries where the missing data rendering them incomplete in the original survey are not relevant to this inquiry. (15)

The survey, while far from a complete census, provides a good view of the larger Lancashire cotton firms. There were

somewhat less than 1,000 cotton firms in Lancashire at this time; the survey included about one-third of them. The data for just over half of the firms surveyed can be used here, making for a one in five or so sample. This sample is biased toward large firms. The average employment was 322 persons, compared to 193 for all firms eight years later. And Gatrell argues that the survey was quite inclusive of the larger firms: "Omissions in the 1933 listing become numerous only lower down the scale: it lists only 43 of the known 96 Manchester firms of 1832." (16) Even though Gatrell remarked on the failure of the survey to catch every firm, representation by half of the "known" firms is more than adequate here.

The average count of yarn spun by these mills was 51. The mills were classified as "fine spinning" and "coarse spinning" according to whether they spun counts below or above 90. This is a very high count, both by contemporary American and even later British standards. A two-by-two table (Table 1) shows the association between fine spinning (d90=1) and integrated operation (dw=1). (17) The chi-square equals 17.6, showing that the two variables are related. Almost all integrated firms (97.5%) were engaged in coarse spinning. Only two fine-spinning firms also employed weavers. (18)

This finding can be expanded into the following model:

(1) $\quad \text{Prob}(dw=1) = F(a - b\ \text{count} + c\ \text{spin})$.

The probability that a mill was integrated is hypothesized to be

a negative function of the average fineness of yarn spun (count). I also argue that owners of larger factories could raise capital more cheaply than smaller operators, so that the probability of integration was a positive function of the size of the factory, which I measure by the number of spinners (spin) to avoid interaction between the size variable and the probability of integration. The results of a logit estimation of equation (1) are shown in top part of Table 2. Both coefficients are significantly different from zero in the expected direction. The logit regression predicts correctly 71 percent of the mills, while the implicit hypothesis of Table 1 (fine spinners are specialized; coarse spinners, integrated) correctly classifies 60 percent. (The two models misclassify very different firms, of course.)

Among integrated mills (dw=1), the number of weavers should be affected by the same variables as in equation (1). If mills generally spin a distribution of counts, then mills with a lower average count should be able to weave more of their own yarn. Mills spinning more yarn could employ more weavers to weave it. Consequently the number of weavers employed in integrated factories (weave) should be a function of the same variables in Equation (1):

$$(2) \qquad weave = a' - b'\ count + c'\ spin + u.$$

Estimating Equation (2) by OLSQ yields the results shown in the lower part of Table 2. Again, both coefficients have the

expected sign and are highly significant. On average, one weaver was added for every two spinners, and an increase of yarn count by ten reduced the expected number of weavers by 50. About 1/3 of the variation in the number of weavers is explained by this simple model.

As suggested above, the count spun and the size of mills was not completely independent. Assuming that the choice of count was independent, it had a significantly positive effect on the size of spinning mills. Since a higher count discouraged integration while larger size encouraged it, the indirect effect of count offset in part its direct effect. The offset, however, was small. For while the association between the count and the number of spinners was clear (t=5.1), only 13 percent of the variation in the number of spinners is explained by the count.

Vertical integration in the early Lancashire cotton industry therefore was closely connected with the progress of technology. The integration of spinning and weaving offered some savings in the transactions cost between the two activities, but only to those firms that could weave their own yarn. Only firms spinning coarse yarn, therefore, had their own power looms.

This result confirms the importance of transaction costs. The integrated firms were saving on the transaction costs of selling and then buying yarn. But these costs were not large relative to the costs of manufacture. Integrated and specialized firms coexisted with only a moderate trend toward integration. And the relative costs of power-loom weaving for different grades

of cloth were important in determining which firms were integrated. The shape of the firm was dictated by the nature of the product.

Vertical Integration in the United States

As in Britain, the first cotton factories in the United States were spinning mills. Samuel Slater brought the knowledge of the new spinning machinery to the United States and began production in 1791. The first integrated firms appeared in 1814 when the Bostom Manufacturing Company began producing cloth made on power looms built by Paul Moody from sketches and calculations of the Horrocks loom brought back from England by Francis Lowell. This was the same loom that was not used widely in Britain because it could only weave "plain goods." If the Americans were indeed using roughly the same technology as the British, the Waltham mill of the Boston Manufacturing Company should have been making the most basic kind of cloth. And it was. In Nathan Appleton's oft-quoted words: "The article first made at Waltham, was precisely the article of which a large portion of the manufacture of the country has continued to consist; a heavy sheeting of No. 14 yarn, 37 inches wide, 44 picks to the inch, and weighing something less than three yards to the pound." (19) The number of the yarn is its count, which is defined to be the number of hanks of yarn (840 yards) in a pound. Number 40 yarn therefore is twice as fine (weighs half as much) as number 20 yarn. Picks are the number of wefts, and the weight is reported inversely as yards per pound in the fashion of the cotton

industry. This yarn and the resultant fabric was far heavier and coarser than those made in Lancashire.

Integrated American mills continued to produce heavy fabrics throughout the early nineteenth century. A letter to Appleton contains the plans for a new integrated factory in Lowell in 1824: "I should think the machinery for the first factory [of the new Hamilton company] should be built one-half to spin about No. 20, the other half, no. 40 to 44. The number 20, warp and filling, would be suitable for the twilled stripes you have seen, and for stout jean for bleaching and printing. The No. 40 would make very good dimity, or fine jean, and would be suitable for doubling, for warps for derries, to be filled with No. 20." (20)

Number 40 yarn, however, was too fine, as shown by a report to a meeting of the Lowell proprietors in 1827: "The fine goods which we made are found to be worth very little more than those of a coarser description; and, costing much more, it was thought expedient to change one-half of Mill No. 1, in which we spun No. 40 yarn, to the same coarseness as the other half, of No. 22, which has been done at trifling expense, not more than two or three hundred dollars, so that, at present, the whole of that mill is employed making jeans, stripes and cords, of No. 22 yarn." (21)

Another Lowell mill was planned in Lowell in 1827 to make exactly the same fabric as the original Waltham heavy sheeting made from number 14 yarn. This was, of course, a much coarser

fabric than the English were exporting to the U. S. The imported English shirting was a "thin and unserviceable fabric" that weighed only five or six yards to the pound. The light weight shows that the English fabric was woven from yarn of count approximately double that used in the integrated American mills. (22)

The literature suggests that this was not totally a national distinction. Montgomery asserted that Rhode Island mills, like most British mills, generally spun yarn finer than number 40 in the 1830s. (23) But the data do not support this view. The weight of cloth produced by state in 1931 is shown in Table 3. It is clear that the cloth produced in Massachusetts was not heavier than the cloth produced in other states. In fact, the the Massachusetts weight (3.72 yards per pound) was virtually the national average (3.87 yards per pound).

Data collected in the McLane Report provide a more detailed view for New York. The distribution of mills by count of yarn spun in New York State is compared with the distribution in Lancashire in Table 4. The average count spun in New York was under 20, as in Massachusetts, contrasting strongly with Lancashire. In fact, the distribution shows that there was very little overlap in the type of cotton goods made. Four-fifths of the New York mills spun counts of 20 or less, while less than a tenth of Lancashire mills made comparable products. Three-quarters of Lancashire mills made counts above 30, as opposed to a mere 6 percent of New York mills. The American and British

cotton industries were making different products in the 1830s.

The quality of the American product--at least in the dimension of fineness--did not increase even later in the nineteenth century. The 1860 Census repeated Appleton's description of the heavy sheeting produced at Waltham, adding that these goods comprised "a class of goods which, under the name of `domestics,' have ever since formed the staple of American cotton manufactures." (24) Looking to a later time, the 1890 Census reported as well that "an immense proportion of the goods consumed in the country is coarse and medium fabrics which are the most durable and substantial for every-day wear." (25) Calculations of textile machinery costs in the U. S. throughout the nineteenth century were made for the most representative counts, those in the teens and twenties. (26)

The model estimated above for Lancashire in 1833 explains the American pattern as well. The model predicts that large factories spinning number 14 or even 20 yarn, that is, Massachusetts style mills, had a very high probability of combining spinning and weaving. And, of course, that is exactly what we observe.

Cotton mills outside Massachusetts were smaller; the average employment of New York firms in 1831 was only 64 people. This compares with an average employment of 320 in the Lancashire sample at the same time.) The model used to explain integration in Lancashire can be used for New York, replacing the number of people engaged in spinning and weaving by the number of spindles

and looms. As shown in Table 5, larger spinning mills were more likely to be integrated and have more looms. In New York, however, the range of counts spun was too narrow for the count to have any effect. The early power looms had trouble weaving what were called fine yarns in Manchester, but no one in New York was engaged in fine spinning. Given the range of counts spun in New York, there is no reason to expect that differences among New York mills would have been determined by differences in their products.

As in England, however, the size of spinning mills was positively associated with the count of yarn spun. The association between the two variables was stronger in the United States (t=6.4), and the count spun explained one-third of the variance in the number of spindles. Within the range of counts spun in New York, the indirect of count on size therefore negated the direct effect. Only in the higher counts spun in Lancashire was the direct effect stronger.

The interpretaticn of the American results also is slightly different than the British story. As just noted, the American cotton industry produced a different product than its British analogue. In addition, the largest American spinning mills were constructed by the owners of the power-loom patents. Almost no integrated mills in Lancashire had similar origins.

Assuming for the moment that the first of these characteristics is given, the second is not hard to explain.

Lowell, Appleton, and their friends were in possession of an initially scarce resource: the patented knowledge of how to build a power loom. They were in a good position to raise capital for the exploitation of this resource. The use of power looms clearly had an externality for the spinning industry; demand for yarn would rise. The owners of the power looms wanted to internalize this externality, which they could do by owning both weaving and spinning factories. And since their looms only wove the roughest of yarns, they invested in mills that spun the low counts of yarn that the looms could handle. Despite the differences, therefore, the limited range of the early power looms was an important determinant of the products made by integrated mills in both Massachusetts and Lancashire.

Differential access to capital markets (coupled with incentives to borrow) was important also. Lowell's connection with the Boston financial community are well known. It appears that his successors exploited this connection as well, in a way that shifts the argument from the boundary of economics and technology to the boundary of economics and politics.

A provision in the 1819 treaty acquiring East Florida from Spain provided for U. S. assumption of claims from private citizens against Spain. Many of these claims had arisen out of Spanish raids on U. S. merchant shipping and were held by Boston insurance companies, which were owned in turn by Appleton and other investors in the Boston Manufacturing Company. Daniel Webster, acting on commission from the Boston insurance

companies, negotiated a generous settlement from the federal government in 1821. The resulting influx of capital to Boston coincided with the development of Lowell. While no direction can be found, this windfall gain must have encouraged the Lowell investment. (27)

The remaining question then is why American mills produced such low-quality goods. The traditional answer cites the frontier character of American demand, as noted in the 1890 Census. But this is only part of the story, for these rough cloths were made also in India and China (in part from English yarn). We need to explain why American firms produced these heavy fabrics instead of importing them.

The link between economics and politics is stronger and better documented here. The American firms found it profitable to spin and weave number 14 and 20 yarn because Francis Lowell, the founder of the Boston Manufacturing Company, designed the relevant part of the Tariff of 1816 for that end.

The tariff was a response to the influx of British goods following the end of the war with Britain. It set a duty of 25 percent on cotton textiles, but--in response to an argument by Lowell--introduced a minimum valuation of 25 cents. The tariff, in other words, was a specific duty of 6.25 cents for all fabrics priced below 25 cents a yard and an ad valorem duty for finer fabrics.

Lowell lobbied for a minimum in order to protect his nascent

Waltham mill. His product was designed "to imitate the yard wide goods of India, with which the country was then largely supplied." (28) But even with the power loom, the Massachusetts mill could not compete with the Indian producers. Lowell needed a very high tariff to survive. (29) But he knew could not get Congress to levy a high enough ad valorem rate; Southern cotton growers sold most of their output on the British market, and they refused to agree to anything that would decrease the demand for English cotton textile products or that might even provoke retaliation.

Lowell therefore proposed a tariff structure that would discriminate against Indian cottons, but not the higher priced English fabric. He sent a memorial to Congress to that effect. Fortunately for the historian, it was quoted in a later pro-tariff memorial, anonymously to be sure. The context and Appleton's description of Lowell's argument permit the identification. In Lowell's words: "The articles, whose prohibition we pray for, are made of very inferior materials,...No part of the produce of the United States enters into their composition. They are the work of foreign hands on foreign materials." (30) The minimum, in other words, would exclude only Asian cloth made from Asian cotton; it would not affect either the demand for higher quality English cloth made from American cotton. This argument won the support of South Carolina, which saw the minimum as a measure to protect the domestic market for their raw cotton, and assured passage of the tariff.

Lowell, however, had done more than assure the success of his integrated operation. He had created a tariff that protected rough cottons far more than the finer cottons spun by the Rhode Island mills. The Rhode Island mills competed with English, not Indian, producers, and they were only lightly protected. The vertically specialized firms consequently did not share in the prosperity of Waltham and Lowell. Ware compiled data from the McLane Report showing that Rhode Island firms were just scraping by in the 1820s, as the mills at Lowell multiplied. (31)

Chandler, like many other scholars, looked only at the ad valorem rate, evaluated protection as "mildly protective," and inferred that the integrated American cotton mill was highly efficient. (32) But as Saxonhouse and Wright note, the New England cotton textile industry was never internationally competitive. (33) Bils noted that the effect of the tariff varied with the quality of cloth. He argued that the American cotton industry would not have survived without the tariff; I extend his argument tc say that only the lower end of the American cotton industry could prosper with the tariff--not by accident, but by design. (34)

Conclusion

Lancashire contained a mix of integrated and specialized firms in the early nineteenth century. The majority were vertically integrated, and the trend was in their favor. The main impetus for the integration of spinning and weaving was the

increasing range of power looms, allowing finer fabrics to be factory made. While a transaction cost argument can be constructed to show the advantages of vertical integration, variation in production costs--not transaction costs--explain the pattern of integration among Lancashire firms.

American cotton textile mills combined spinning and weaving for the same reasons as their British counterparts, although the weavers hired the spinners in America, at least initially, in a pattern not seen in Britain. Manufacturing costs for different grades of cotton and comparative capital costs were issues in America, as in Britain. In addition, the political power of the Waltham patent holders had a determining influence on the product mix of the American cotton industry. The greater integration of the American industry reflected the different product mix of the two countries, which owed as much to the shape of the American tariff as it did to the character of American demand.

As in Britain, the combination of weaving and spinning in Massachusetts is explained best by conventional, not transactions, costs. And the factors determining those conventional costs were political as well as technological.

Table 1

********** Crosstabulation of d90 by dw **********

d90	COUNT / COL PCT	dw = 0	dw = 1	ROW TOTAL
	0	64	77	141
		74.4	97.5	85.5
	1	22	2	24
		25.6	2.5	14.5
	COLUMN TOTAL	86	79	165
		52.1	47.9	100.0

Table 2

********** LOGIT ESTIMATION **********

Dependent variable: dw

Independent Variable	Estimated Coefficient	Standard Error	t-Statistic
const	1.22121	0.37630	3.24529
count	-4.31335e-002	1.06041e-002	-4.06762
spin	3.06285e-003	1.10030e-003	2.78364

number of observations 165
percent correctly predicted 71

********* ORDINARY LEAST SQUARES ESTIMATION *********

Dependent Variable: weave

Independent Variable	Estimated Coefficient	Standard Error	t-Statistic
const	2.82693e+002	44.05525	6.41679
count	-5.02819	1.29047	-3.89641
spin	0.58876	9.05603e-002	6.50133

Number of Observations 79
R-squared 0.37

Table 3

SELECTED DATA FOR U.S. COTTON MILLS, 1831

State	Yds of Cloth	Pounds of Cloth	Number of Mills	Yds/lb.
VA	675	168	7	3.87
MD	7,549	2,224	23	3.39
ME	1,750	525	8	3.33
VT	2,238	575	17	3.89
NH	29,061	7,255	40	4.01
MA	79,231	21,301	250	3.72
CT	20,056	5,612	94	3.57
RI	37,122	9,271	116	4.00
NY	21,011	5,298	112	3.97
NJ	5,134	1,877	51	2.74
PA	21,332	4,207	67	5.07
DL	5,204	1,292	10	4.03
TOTAL	230,462	59,605	795	3.87

Source: Friends of Domestic Industry, Reports of the Committees of the Friends of Domestic Industry, assembled at New York, October 1831 (1831), p.12.

Table 4

PERCENTAGE DISTRIBUTION OF COTTON MILLS
BY COUNT OF YARN SPUN, 1831-33

Count	Lancashire	New York
1-10	01	13
11-20	08	67
21-30	21	12
31-40	41	04
41-50	10	02
51-100	09	--
101-150	12	--
Number of firms	165	89
Mean count	51	18

Source: Stanway, S., "Tables Extracted from the Returns to the Lancashire Forms," Parliamentary Papers Volume 19, pp. 415ff (1834); United States, Department of the Treasury, Documents Relative to the Manufactures in the United States (collected by the Secretary of the Treasury, Louis McLane) (collected by the Secretary of the Treasury, Louis McLane) House Executive Document 308, 22d Congress, 1st Session (Washington, 1833).

II, 48-59.

Table 5

********** LOGIT ESTIMATION **********

Dependent variable: dw

Independent Variable	Estimated Coefficient	Standard Error	t-Statistic
const	-1.87939	0.96923	-1.93905
count	8.29763e-002	6.18305e-002	1.34200
spindles	1.11323e-003	4.01945e-004	2.76960

number of observations 89
percent correctly predicted 83

********* ORDINARY LEAST SQUARES ESTIMATION *********

Dependent Variable: looms

Independent Variable	Estimated Coefficient	Standard Error	t-Statistic
const	5.64691	7.09429	0.79598
count	-0.19081	0.40065	-0.47625
spindles	2.60310e-002	2.05727e-003	12.65317

Number of Observations 63
R-squared 0.79

Footnotes

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